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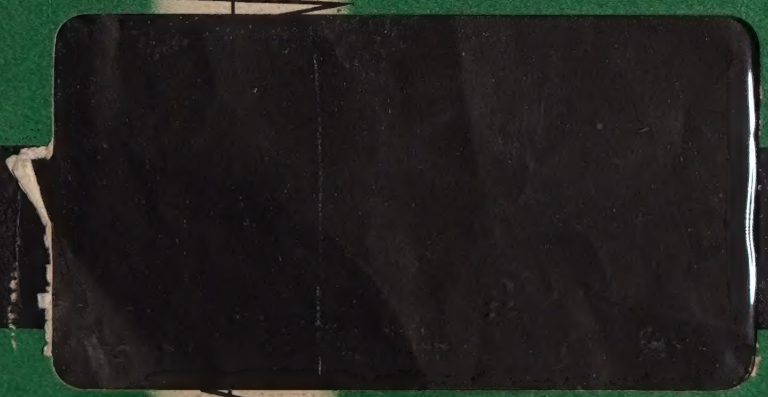

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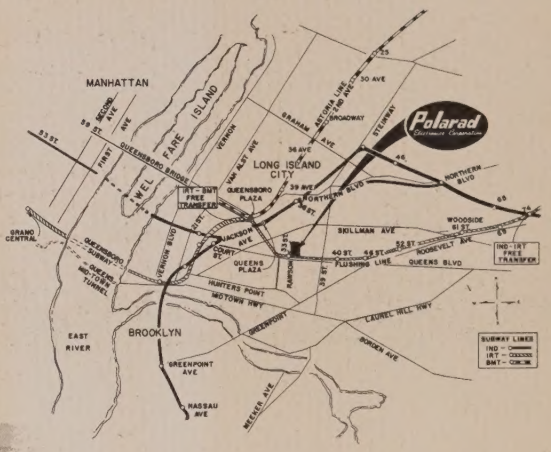

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Instruction Manual

→ NOTE ←

Information and Instructions pertain to the following models and serial numbers:

Basic Unit, Model DU	from Serial No. 131
RF Tuning Unit, Model STU-1	from Serial No. 101
RF Tuning Unit, Model STU-2	from Serial No. 116
RF Tuning Unit, Model STU-3	from Serial No. 116
RF Tuning Unit, Model STU-4	from Serial No. 101
RF Tuning Unit, Model STU-5	from Serial No. 101

POLARAD

MODEL TSA

ALL-BAND, DIRECT-READING

SPECTRUM ANALYZER

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TABLE OF CONTENTS

Section			Page
I.	INTRODUCTION		
	1-1.	Scope of manual	1
	1-2.	Uses of the Model TSA Spectrum Analyzer	1
II.	DESCRIPTION		
	2-1.	General	1
	2-2.	Technical characteristics	2
	2-3.	Equipment supplied	2
III.	OPERATION		
	3-1.	Operating controls	3
	3-2.	Operating procedure	4
IV.	PRINCIPLES OF OPERATION		
	4-1.	General	7
	4-2.	Local oscillator	8
	4-3.	Tuning head crystal mixer	8
	4-4.	Wide band amplifier	9
	4-5.	Narrow band amplifier	9
	4-6.	Oscilloscope (video) circuit	9
	4-7.	Sweeper circuit	9
	4-8.	Marker oscillator	10
	4-9.	Power supplies	10
	4-10.	Mechanical drive system	10
V.	MAINTENANCE		
	5-1.	General	11
	5-2.	Access to the equipment	11
	5-3.	Performance data	11
	5-4.	Trouble shooting	12
	5-5.	Power supply adjustments	14
	5-6.	Blanking width adjust R562	14
	5-7.	Setting the high dispersion limit adjustments	14
	5-8.	Frequency centering negative and positive limit adjustments	15
	5-9.	Narrow band chassis alignment procedure	15
	5-10.	224 mc sweeper alignment	15
	5-11.	Wide band amplifier chassis alignment	16
	5-12.	Marker zero setting	16
	5-13.	Klystron tube replacement	16
	5-14.	Repeller voltage tracking adjustments	17
	5-15.	FREQUENCY IN MEGACYCLES dial adjustment	19
	5-16.	Wide Band-Pass Filter Alignment	21
	5-17.	160 MC Narrow Band-Pass Filter Alignment	21
	5-18.	Low-Pass Filter Alignment Procedure	21

Model TSA Spectrum Analyzer

SECTION I

INTRODUCTION

1-1. SCOPE OF MANUAL.

This instruction manual contains directions for the installation, operation and maintenance of the direct-reading table-top Spectrum Analyzer, Model TSA, covering the frequency range from 10 mc to 44,000 mc. In addition to these instructions, there is a listing of the technical characteristics as well as a brief theory of operation of the equipment. The unit is designed and manufactured by Polarad Electronics Corporation, Long Island City 1, New York.

1-2. USES OF THE MODEL TSA SPECTRUM ANALYZER.

a. Rapid and accurate measurement, and spectral display of the frequency distribution of energy in an rf signal in the 10 mc to 44,000 mc range, depending upon the tuning unit in use. CW and pulsed radio signals are presented visually as a plot of voltage vs. frequency.

b. Specific uses of the equipment are:

(1) Observing and measuring side bands associated with amplitude and frequency modulated signals.
(2) Determining the presence and measuring the frequency of radio and/or radar signals.
(3) Determining the type of modulation in radio and/or radar signals.
(4) Checking and observing the tracking of rf components of a radar system, for example, tracking transmitter and receiver.
(5) Determining rf pulse characteristics.
  (a) Frequency modulation)
  (b) Pulse width) By Spectrum Analysis.
  (c) Pulse shape)
(6) Checking the spectrum of pulsed magnetron oscillators, to determine pulse characteristics and to check frequency pulling.
(7) Measuring noise spectra.
(8) Checking the frequency difference and/or spectrum of two rf signals.
(9) Checking frequency relationships of multi-frequency transmitters, for example, dme transmitters.
(10) Checking for parasitic oscillations.
(11) Testing for interference sources throughout frequency range from any electrical equipment.
(12) Checking transmitter or signal generator for continuous output throughout its tuning range (checking for "holes").
(13) Frequency drift of oscillators.
(14) Locating sources of rf leakage.
(15) Indicator for frequency standards.

SECTION II

DESCRIPTION

2-1. GENERAL.

The Polarad Model TSA Spectrum Analyzer is a laboratory instrument consisting of a complex superheterodyne receiver working into a cathode ray display. Signals in the frequency range from 10 mc to 44,000 mc may be analyzed. It comprises the main chassis, Model DU, and one of the five replaceable RF Tuning Units, STU-1, 2, 3, 4, or 5. Tuning Unit STU-1 covers the range from 10 mc to 1,000 mc; Tuning Unit STU-2 from 910 mc to 4,560 mc; Tuning Unit STU-3 from 4,370 mc to 22,000 mc; Tuning Unit STU-4 from 21,000 mc to 33,000 mc; and Tuning Unit STU-5 from 33,000 mc to 44,000 mc. The rf tuning Unit receives cw and pulsed rf signals and converts them to an intermediate frequency of 160 mc, which is amplified, reconverted, and detected by the various circuits within the Model DU. Signals detected are presented on a cathode ray tube screen as a plot of voltage versus frequency, with voltage on the vertical axis and frequency on the horizontal axis. Controls are provided on the front panel for continuously adjusting the spectrum bandwidth observed on the screen from a band of frequencies as narrow as 400 kc to a band as wide as 25 mc, as desired. The Model DU consists of six sub-chassis secured together on a single frame. In operation, a tuning unit is inserted into the frame and the two front panels combine to appear as a single, continuous panel. All required voltages are provided by four electronically regulated power supplies and one unregulated supply incorporated into the main chassis. The unit is portable and designed for either bench, wagon, or rack mounting.

2-2. TECHNICAL CHARACTERISTICS.

Frequency Range:	
With RF Unit STU-1	10 mc to 1,000 mc.
With RF Unit STU-2	910 mc to 4,560 mc.
With RF Unit STU-3	4,370 mc to 22,000 mc.
With RF Unit STU-4	21,000 mc to 33,000 mc.
With RF Unit STU-5	33,000 mc to 44,000 mc.
Spectrum Display	Voltage on the vertical axis versus frequency on the horizontal axis.
Resolution Bandwidth (3 db)	25 kc at all frequencies.
Frequency Dispersion	400 kc to 25 mc, adjustable.
Sweep Repetition Rate	1 cps to 30 cps, adjustable.
Sweeper Center Frequency	224 mc.
Synchronization	Either line frequency internal, negative external pulse, or free running.
Intermediate Frequencies:	
1st i-f	Three-stage stagger-tuned amplifier tuned to a 160 mc center frequency with a bandwidth of 25 mc (3 db).
2nd i-f	64 mc.
3rd i-f	6 mc.
4th i-f	500 kc.
Frequency Marker	288 mc ±14 mc.
RF Tuning Dial Accuracy	±1% or ±2 mc whichever is greater
Sensitivity (minimum discernible signal).	
RF Unit STU-1	Low range: -87 dbm. High range: -83 dbm.
RF Unit STU-2	Low range: -87 dbm. High range: -77 dbm.
RF Unit STU-3	Low range: -75 dbm. High range: -60 dbm.
RF Unit STU-4	-55 dbm.
RF Unit STU-5	-45 dbm.
Over-all Gain	120 db.
Attenuation:	
RF (STU-1, STU-2, STU-3 only)	100 db, continuously variable.
IF	60 db, continuously variable.
Input Impedance	50 ohms (nominal).
Max. RF Power Input (through attenuator)	250 milliwatts.
Power Input	400 watts at 115 or 230 volts ±10 volts, 50 to 60 cps.
Tube Complement:	
DU	4-5R4; 2-807; 4-6AU6; 6-0A2; 1-6X4; 2-6AS7G; 1-6AR6; 2-1X2A; 1-5ADP7; 2-6BA7; 2-6AG5; 3-6AJ4; 2-6J6; 2-6CB6; 1-6AS6; 3-12AT7; 1-6J4; 2-12AU7; 9-6AK5; 1-115NO60 (relay).
STU-1	1-6AF4; 1-1N21B; 3-6AJ4.
STU-2	1-5837 or 6BM6; 1-6X4; 1-1N21B.
STU-3	1-5721; 1-6X4; 1-1N26.
STU-4	1-5721; 1-6X4; 1-1N26.
STU-5	1-5721; 1-6X4; 1-1N53.
Dimensions:	17-1/8 in. wide x 19-1/2 in. high x 23-1/8 in. deep.
Weight:	170 pounds; 225 pounds crated.

2-3. EQUIPMENT SUPPLIED.

The equipment supplied with the Model TSA Spectrum Analyzer is listed in Table I.

TABLE I. EQUIPMENT SUPPLIED

Item	Part or Model No.
Spectrum Analyzer main chassis	Polarad Model DU
RF Tuning Unit*	Polarad Model STU-1, STU-2, STU-3, STU-4, and STU-5.
Spanner wrench	J. H. Williams, #482
Line cord	
Type N Adapter	Polarad CSIJ1700**
Waveguide Adapters	Polarad BP20947**; B24550**; BP22330***; BP22331***

*Model TSA includes one RF Tuning Unit. **Supplied with Model STU-3 only. ***Supplied with Model STU-4 only.

SECTION III

OPERATION

3-1. OPERATING CONTROLS.

All operating controls are located on the front panel. Table II lists the controls and their functions.

TABLE II. OPERATING CONTROLS AND CONNECTIONS

Controls or Connections	Function
● HOR GAIN	Varies the gain of the horizontal-deflection amplifier and hence the length of the horizontal trace on the cathode ray tube screen.
0 HOR POS	Shifts the trace left or right on the cathode ray tube screen.
● VERT GAIN	Varies the gain of the vertical deflection amplifier and hence the height of the display appearing on the screen.
0 VERT POS	Shifts the trace up or down on the cathode ray tube screen.
H BAL	When properly adjusted, prevents the horizontal gain control from having a horizontal centering effect.
INTENSIFIER	Sets the amount by which the signal on the cathode ray tube screen is intensified.
CENTER FREQUENCY FINE COARSE	Controls the center frequency of the sweeper. FINE is used at low dispersion*.
SWEEP SPEED	Permits adjustment of sweep repetition rate, within the limits of 1 to 30 cycles per second.
DISPERSION	Varies the number of megacycles displayed.
FREQUENCY DIFFERENCE	Permits relocating the marker pip within plus or minus 14 megacycles of i-f center.
I-F GAIN	Controls sensitivity of the i-f amplifier.
MARKER AMPLITUDE	Varies the height of the marker pip on the screen, when the MARKER switch is set to its ON position.
SYNC SELECTOR	Determines the type of synchronization, power line frequency or external.
SYNC LEVEL	Varies sync amplitude to lock the sweep generator.
POWER switch	Closes the circuit in the primary of the power transformers to apply ac power.
POWER pilot light	Indicates that power is applied to energize the system, except the klystron power supply.
KLYSTRON pilot light	Indicates completion of the 60-second delay cycle and application of power to the klystron power supply**.
MARKER ON-OFF	Applies operating power to the marker oscillator within the equipment.
FOCUS	Focuses the trace on the scope screen.
BRIGHTNESS	Sets the general brightness level of the trace on the cathode ray tube screen.
SCALE ILLUM	Controls illumination of the graticule.
EXT SYNC INPUT	External sync input connection.
TUNING	Controls the operating frequency, as indicated on the direct-reading frequency dial.
RF ATTENUATOR***	Attenuates the incoming signal down to 100 db, adjustable.
ATTENUATOR*** RF INPUT	RF input connection for high level signal (greater than -50 dbm) to be applied through the attenuator.
DIRECT RF INPUT	RF input connection for low level signal, utilizing maximum sensitivity of instrument.
ATTENUATOR OUTPUT (Connector)	In the Models STU-1 and STU-3 a patch is required to feed the signal from the attenuator to DIRECT RF INPUT. This connector in the Models STU-1 and STU-3 only.

*"low dispersion" being defined as minimum megacycles displayed.
**STU-2 through STU-5 only.
***STU-1 through STU-3 only.

3-2. OPERATING PROCEDURE.

a. Setting Up the Equipment.

CAUTION

THE EQUIPMENT MAY BE DAMAGED IF OPERATED AT 230 VOLTS WHEN SET FOR 115 VOLT OPERATION. EXAMINE THE TAG ATTACHED TO THE POWER SWITCH ON FRONT PANEL AND NOTE THE INITIAL FACTORY SETTING. THE SETTING MAY BE CHECKED BY REMOVING THE DUST COVER AND EXAMINING THE POSITION OF THE CONTROL SWITCH ON THE LEFT HAND SIDE OF THE CHASSIS.

(1) Connect plugs P103 and P104, which terminate the 2 cables from the main chassis, to the power and signal jacks on the rf tuning unit. Connect power cord to ac source.

(2) Turn the POWER switch to its ON position. The POWER indicator should light. After a 60-second delay, the KLYSTRON indicator should light*. Allow a 10 minute warm-up period.

(3) Set the BRIGHTNESS, VERT POS, VERT GAIN, HOR POS, HOR GAIN and FOCUS controls to produce a sweep base line, centered on the screen. This procedure is identical to the setup for any oscilloscope.

(4) Set the DISPERSION control maximum clockwise and the IF. GAIN control to give noise of desired height on screen (approximately 1/4 inch).

(5) Turn the MARKER switch to its ON position and the MARKER AMPLITUDE control completely clockwise. Turn the FREQUENCY DIFFERENCE control to zero. This operation places the marker pip at the electrical center of the display. If the marker pip is not visible or is not in the center of the display screen, vary the CENTER FREQUENCY control until the pip is properly centered on the display baseline. Set the MARKER AMPLITUDE to give desired marker height.

(6) Connect the signal under test to the DIRECT RF INPUT (if signal is less than -50 dbm) or to the ATTENUATOR RF INPUT** (if signal is greater than -50 dbm). Check to see that the rf tuning unit being used falls within the range of the signal. (See paragraph 2-2.)

(7) Rotate the TUNING control until a pip, representing the incoming rf signal, appears at the center of the screen. If the display is excessively large, vary either the RF ATTENUATOR (when used), the IF. GAIN, and/or the VERT GAIN controls to set the height of the pip. (Use the VERT GAIN control as a final adjustment).

(8) Adjust the spectrum dispersion by varying the DISPERSION control. This control sets the band of frequencies covered by the sweep-oscillator circuit. Frequency dispersion can be varied within the limits of 400 kc to 25 mc except in the 10 to 45 mc range of the Model STU-1 Tuning Unit. On that range, the maximum usable frequency dispersion is 5 mc.

b. Determining the Frequency of an Applied RF Signal.

The spectrum display is designed to indicate increasing frequency of input signal from left to right. Note that rotating the frequency dial to a higher frequency with a fixed signal will cause the signal on the screen to move left.

(1) Set the marker to the electrical center of the display as directed in step (5) of the previous subparagraph.

(2) Slowly rotate the TUNING control until the signal pip merges with the marker pip. Read the frequency of the incoming rf signal directly from the frequency dial. It is important to determine which of the calibrated scales is to be read and to distinguish between the true signal and the image. Proceed as follows: Set the DISPERSION control maximum clockwise and rotate the tuning dial 10 mc towards the higher frequency and note the movement of the pip. If the pip moves to the left, it is the true signal except as noted below#. If the pip moves to the right, it is the image. The true signal pip will then be found 320 mc higher than the image. If the signal pip moves off scale, read the high range scale. If the signal pip moves 10 mc, read the low range scale. If the pip remains stationary on the screen it is a spurious response due to a signal falling within the i-f pass-band (148 - 172 mc).

c. Determining the Width of any Lobe of a Signal Spectrum.

(1) Note that the FREQUENCY DIFFERENCE control is calibrated from minus 14 to plus 14 megacycles. Vary the FREQUENCY DIFFERENCE dial so that the marker pip is coincident with one edge of the lobe whose width is to be measured. Record the setting of the dial.

(2) Rotate the FREQUENCY DIFFERENCE dial so that the marker pip is coincident with the other edge of the lobe being measured. Record the setting of the dial.

*STU-2, STU-3, STU-4 and STU-5 only.

**In the Models STU-1 and STU-3 only, it is also necessary to patch from ATTENUATOR OUTPUT to DIRECT RF INPUT.

#In the Model STU-1, spurious responses at 10.7 mc and at 16 mc will appear and move to the left. These spurious responses appear as a result of the beating of the local oscillator fundamental or its harmonics, with the 112 mc sweeper signal or its harmonics. To determine whether the input signal is being observed, reduce the amplitude of the input signal. If the amplitude of the pip on the display screen changes, it is the true signal. If the amplitude remains constant, the pip represents a spurious response.

(3) Calculate the difference in megacycles between the settings of the FREQUENCY DIFFERENCE dial in steps (1) and (2) above. This figure is the width in megacycles of a particular lobe appearing in the display.

d. Measuring Frequency Difference.

The procedure described in paragraph c. is also applicable to measuring frequency difference between any two signals appearing in the display.

e. Measuring the Incidental FM of an Applied Signal.

To measure the incidental fm of a signal applied to the spectrum analyzer proceed as follows:

(1) Apply the signal to the input of the spectrum analyzer and set the controls to view the resultant pulse.
(2) Vary the DISPERSION control to set the main lobe to three-quarters of the screen diameter.
(3) Use the marker pip and calibrate the bandwidth from one side of the scale to the other. Divide the bandwidth figure by 10 to find the frequency change-per-scale division.
(4) Set the SWEEP SPEED control to minimum (maximum counterclockwise).
(5) Draw two lines to indicate the pulse envelope. (See lines (A) and (B) of figure 1.) Draw a horizontal line (C) from one side of the envelope to the other. Drop two vertical lines (D) and (E) to the base from the two points on the inner and outer edges of the envelope crossed by the horizontal line (C).

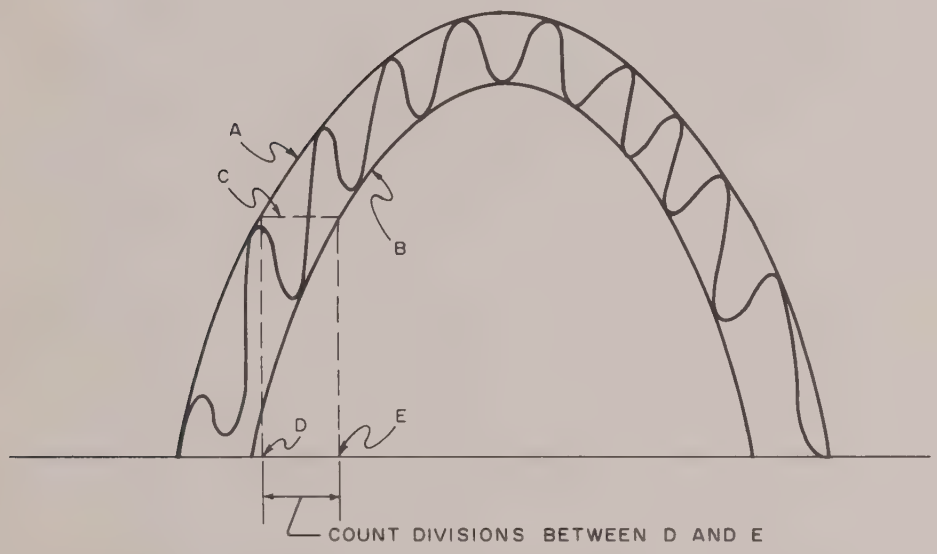


Figure 1. Measuring Incidental FM

(6) Count the number of divisions between lines (D) and (E) at the base. Use the frequency change-per-scale division from step (3) above to calculate the frequency change. This frequency change represents the incidental fm of both the applied signal and that inherent within the spectrum analyzer.
(7) To determine the fm of the applied signal it will be necessary to measure the incidental fm of the spectrum analyzer and to take this incidental fm and its phase angle into consideration. To measure the incidental fm of the analyzer, follow the procedure for measuring the incidental fm of an applied signal except that the signal applied should be the output of a cw generator known to be free of fm.

f. Applied Pulse VS Power Spectra.

Figure 2 illustrates the resultant spectrum when certain rf pulses are applied.

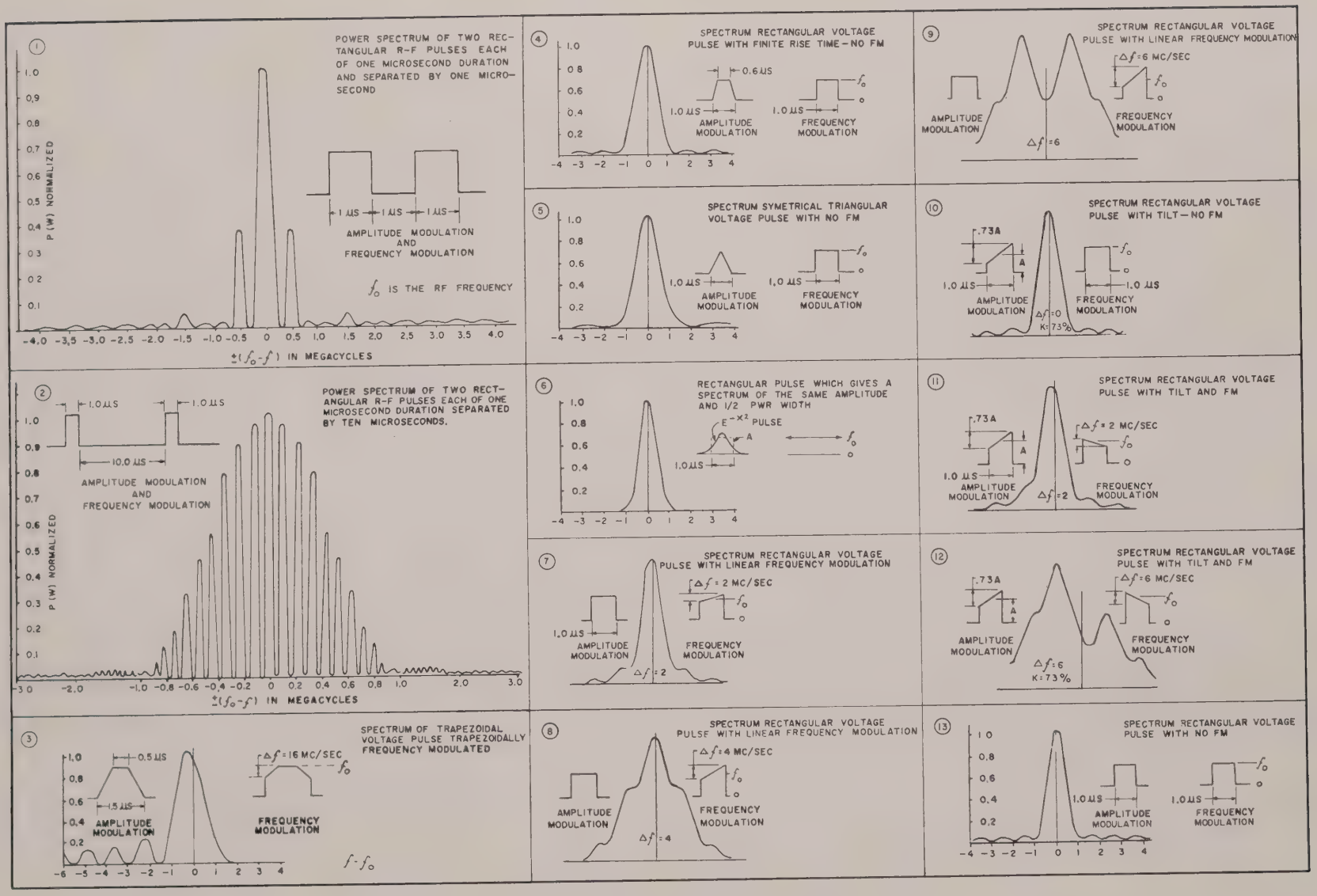


Figure 2. Applied Pulse VS Power Spectra

SECTION IV

PRINCIPLES OF OPERATION

4-1. GENERAL.

The principles of operation of the Polarad Model TSA Spectrum Analyzer may be understood from the block diagram of figure 3. The Models STU-2, STU-3, STU-4 and STU-5 RF Tuning Units each contain an external cavity klystron local oscillator, a crystal mixer, a tracking potentiometer and adjustment panel, and a mechanical drive system. The Model STU-1 contains a local oscillator using a triode tube in a tuned transmission line circuit, a crystal mixer, a stagger-tuned preamplifier and a mechanical drive system. The units are each tuned manually by rotating the single TUNING knob, located at the center of each front panel.

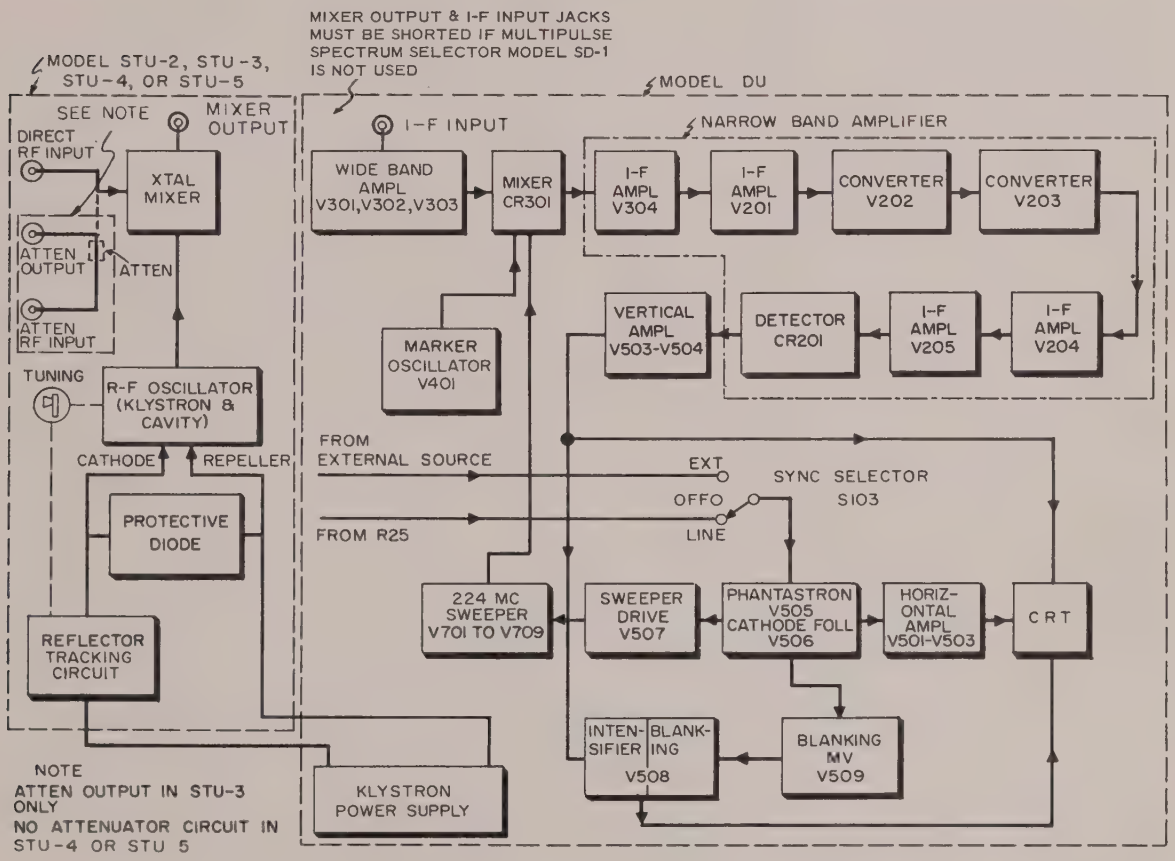


Figure 3. Block Diagram - Signal Paths - Model TSA

In the Model STU-1, rotation of the TUNING knob drives a shorting element across the tuned transmission line and, simultaneously, the tuning dial. In the other units, rotation of the tuning knob simultaneously drives a non-contacting choke within the oscillator cavity, a tracking potentiometer for changing reflector voltage automatically, and a tuning dial. The dial indicates frequency in megacycles accurately to ±1%. The main chassis, Model DU, consists of a broad band and a narrow band i-f amplifier, a variable-frequency marker oscillator, a sweeper circuit, a 5-inch cathode-ray oscilloscope with its associated driving circuits and four power supplies (fig. 7). The Models STU-1, STU-2 and STU-3 RF Tuning Units cover their respective ranges in two

bands* each. Signals in a 25 mc** bandwidth, centered at the frequency to which the unit is tuned, are received and converted to 160 mc (the first intermediate frequency). This 160 mc voltage is fed by coaxial cable to the wide band amplifier in the main chassis, Model DU. The output of the wide band amplifier is fed into the mixer of the wide band amplifier. The local oscillator swept injection of the 224 mc sweeper and the output of the marker oscillator are also fed into the mixer of the wide band amplifier. The resultant i-f center frequency of 64 mc is amplified by the narrow band amplifier. The last two stages of the narrow band amplifier have a bandwidth of 25 kc which effectively results in a resolution of 25 kc at all input frequencies. In addition to the usual scope controls, means for adjusting the center frequency, and frequency limits of the sweep oscillator are provided. An unusually distinct spectrum display is obtained by beam intensification for the duration of the signal. The variable-frequency marker can be used to determine frequency differences of as little as 400 kc. It calibrates the spectrum display and helps determine frequency difference with great accuracy. A description of each of the components of Model TSA follows:

4-2. LOCAL OSCILLATOR.

a. Model STU-1 employs a 6AF4 triode tube in a tuned transmission line oscillator circuit. In the low range (10 mc to 400 mc) the local oscillator fundamental is tuned 160 mc above the incoming signal. In the higher band of operation (400 mc to 1,000 mc), the second harmonic is used to heterodyne with the incoming signal and is also operated 160 mc above.

The parallel transmission line operates in a 1/4 wave mode and is tuned by changing the position of a contacting short circuit. Rotation of the tuning dial changes the position of the contacting short.

b. In the Models STU-2, STU-3, STU-4 and STU-5, a reflex klystron tube is employed as the first local oscillator. In the lower band of operation#, the local-oscillator is 160 mc higher than the signal frequency. In the higher band of operation, the second harmonic frequency of the local-oscillator is used to heterodyne with an incoming signal. In this band, the local-oscillator second harmonic frequency is 160 mc higher than the signal frequency.

The external cavity klystron oscillator functions with a 3/4 wavelength cavity mode. The oscillator is tuned by changing the position of a non-contacting short-circuiting choke assembly within the cavity and by changing the value of the reflector voltage. The Model STU-2 Tuning Unit employs the 1-3/4 reflector mode over the frequency range from approximately 910 mc to 1,500 mc. In the vicinity of 1,500 mc, the reflector voltage becomes excessively high and mode-switching is therefore employed. At the mode switch-point a microswitch is activated by a nylon cam, on the tracking potentiometer shaft, reducing reflector voltage to the proper range for 2-3/4## reflector mode operation. A friction drive is employed in the tuning mechanism. Rotation of the tuning dial drives the oscillator choke assembly. The voltage applied to the reflector electrode of the klystron tube is simultaneously tracked with the tuning dial rotation by means of a tracking potentiometer. A 6X4 protects the klystron by preventing the reflector from going positive with respect to the cathode.

4-3. TUNING HEAD CRYSTAL MIXER.

a. A silicon crystal diode is employed as the mixer, which develops a beat signal of 160 mc when the fundamental frequency of the local oscillator and the applied signal in the low range of the tuning unit are coupled to its input. For example, when in Model STU-2 an rf signal of 940 mc is applied through the RF INPUT jack to the crystal mixer, the local oscillator is tuned to produce an output voltage of 1,100 mc. The resultant difference frequency of 160 mc is fed to the input of the wide band amplifier+.

b. When tuning over the high range, the second harmonic of the local oscillator frequency is used to beat with the incoming rf signal. This second harmonic component is actually developed in the crystal mixer, due to the mixer's non-linear characteristics. For example, when the STU-2 Tuning Unit is tuned to a signal frequency of 2,040 mc, the fundamental local oscillator frequency is 1,100 mc. The second harmonic of the oscillator frequency is then 2,200 mc. This second harmonic component beats with an incoming 2,040 mc signal to produce a difference frequency of 160 mc, which is fed to the wide band amplifier.

---

*STU - 1 - 10 mc to 400 mc (low range); 400 to 1,000 mc (high range)
STU - 2 - 910 mc to 2,200 mc (low range); 1,980 mc to 4,560 mc (high range)
STU - 3 - 4,370 mc to 10,920 mc (low range); 8,900 mc to 22,000 mc (high range)

**Except for the 10 to 55 mc range of the Model STU-1 which has a 5 mc bandwidth.

#STU - 4 and STU-5 have one band only.

##Model STU - 2 (serial numbers 308 and above) employs the 2-3/4 reflector mode over its entire range.
Model STU - 3 employs the 2-3/4 reflector mode from 4,370 mc to 7,800 mc. Mode-switching to the 4-3/4 mode occurs at about 7,800 mc.
Model STU - 4 employs the 2-3/4 reflector mode from 21,000 mc to 23,240 mc. Mode-switching to the 4-3/4 mode occurs at about 23,240 mc.
Model STU - 5 employs the 4-3/4 reflector mode over its entire range.

+The STU - 1 only, uses an additional wide band amplifier. The operation of this amplifier is identical to that of the wide band amplifier described in paragraph 4-4. After amplification by the STU-1 wide band amplifier, the 160 mc signal is fed through a low-pass filter and a wide band pass filter. The function of the filters is to reduce spurious response. In the 10 to 55 mc range the signal is also passed through a narrow band-pass filter. In this range power is applied through switch S601 to relay K501. Operation of the relay reduces the dispersion limit to 5 mc. The 160 mc output of the filters is fed to the input of the wide band amplifier (DU).

4-4. WIDE BAND AMPLIFIER (DU).

The wide band amplifier receives signals from the rf tuning unit at a frequency of 160 mc, and amplifies them. The wide band amplifier amplifies signals in a band 25 mc wide, centered at 160 mc. It contains three type 6AJ4 tubes. The first tube V301 acts as an impedance transformer, matching the input of the amplifier to the cable that transmits the signals present in the output of the rf tuning unit. Tubes V301, V302, and V303 comprise a stagger-tuned triplet. The first stage is tuned to the center of the pass-band at 160 mc, the second stage is tuned to 149 mc, and the final stage is tuned to 171 mc. The output of the wide band amplifier, and the output of the frequency-modulated second local oscillator (operating at a center frequency of 224 mc) are applied to crystal mixer CR301. The resultant beat frequency of 64 mc is fed to the narrow band amplifier.

4-5. NARROW BAND AMPLIFIER.

The narrow band amplifier is mounted on the right side frame of the unit, except the first stage, V304 which is mounted on the wide band amplifier chassis. The function of the narrow band amplifier is to amplify and convert the 64 mc output of crystal mixer CR301 to produce a 500 kc center-frequency i-f with a 25 kc bandwidth. The circuit consists of six stages, V304, and V201 through V205. The 64 mc center-frequency output of crystal mixer CR301 is amplified by tube V304 and fed through an RG-55/U cable to the remainder of the narrow band amplifier. The 64 mc signal is further amplified by a second stage, V201. The bias of this stage and thus the gain of the narrow band amplifier is controlled by the front panel control I-F GAIN R401, on the marker chassis. The 64 mc signal is then coupled to the amplifier section of the third stage, V202, which functions as a converter. The oscillator section of V202, tuned to 70 mc, mixes with the applied 64 mc signal to produce a 6 mc output. The fourth stage, V203, also functions as a converter. In this converter the oscillator section is tuned to a frequency of 6.5 mc. The resultant .5 mc beat signal is amplified by i-f amplifier tubes V204 and V205 and is coupled to crystal detector CR201. The detected output is fed to the CRT vertical amplifier on the video chassis. The resolution of the spectrum analyzer is 25 kc, constant at all frequencies, input and sweep, and is determined by the 25 kc bandwidth of the 500 kc stages of the final i-f amplifier.

4-6. OSCILLOSCOPE (VIDEO) CIRCUIT.

The oscilloscope circuit is mounted on the Model DU chassis to the left of the cathode ray tube, as viewed from the front of the unit. The vertical input deflection voltage is fed from crystal detector CR201 (in the narrow band amplifier) to the grid of V504. Tubes V503 and V504 both phase invert and amplify the signal, providing a balanced output to the vertical deflection plates of V124, the cathode ray tube. Part of the output of V504 is fed to the intensifier section of V508 and can be controlled by the INTENSIFIER potentiometer R535. The output of V508 is coupled to the control grid of the CRT and serves to intensify the beam for the duration of the signal. Tube V505, the waveform generator, is connected in a phantastron circuit with cathode-follower V506, a twin-triode (one half of V506 is not used in the circuit). V505 is triggered by pulses at the power line frequency when the SYNC SELECTOR switch S103 is in its LINE position. In this position a pulse obtained across R125 in the low voltage negative power supply is coupled to the suppressor of V505. In EXT position of the SYNC SELECTOR switch an external pulse may be applied to trigger V505 through the EXT SYNC INPUT jack on the front panel. The repetition rate of V505 may be continuously varied from 1 to 30 cycles per second by the SWEEP SPEED potentiometer R533. One part of the output of V505 is taken by cathode follower V506 and directly coupled through relay K501 and a balanced network to the grid of sweeper drive V507. The output of V507 is directly coupled to the reactance tube V701 of the 224 mc sweeper circuit. A second part of the output of V506 is fed to the grid of V502 and can be controlled by HOR GAIN control R518B. Tubes V502 and V501 are connected in a circuit similar to tubes V503 and V504. Both serve to phase invert and amplify the sawtooth waveform output of V505, providing a balanced sweep signal to the horizontal deflection on the plates of the cathode ray tube, V124. A third part of the output of V505, corresponding to the retrace of the sweep, is taken from its screen grid and used to trigger the blanking pulse generator, V509. This stage functions as a one-shot multivibrator. The blanking pulse output of this stage is fed through one section of the blanking-intensifier amplifier V508 to the control grid of the CRT. The polarity is such that the pulse blanks the electron beam for the duration of the sweep retrace.

4-7. SWEEPER CIRCUIT.

The sweeper circuit is on a demountable chassis which is attached to the right side frame of the basic unit, directly above the narrow band amplifier. The function of the sweeper circuit is to convert the sawtooth wave, provided by the sweeper drive stage, into a variable frequency (frequency dispersion) of the proper amplitude and center frequency for the crystal mixer of the narrow band amplifier. The circuit consists of nine stages, V701 through V709. Input voltage from the sweeper drive stage V507 (in the oscilloscope circuit) is applied at proper dc level to the first tube V701, a reactance modulator, which drives the sweep-oscillator stage V702. The plate tank of this oscillator plus the reactance of the reactance tube is tuned to a center frequency of 28 mc. The third and fourth stages, V703 and V704, respectively, amplify this output signal. The 28 mc signal is then fed to the first frequency doubler stage V705. The output of this stage is amplified by tube V706, and is then coupled to a second frequency doubler V707, producing an output signal of 112 mc. The third and final frequency doubler stage V708 has its plate tank circuit tuned to a frequency of 224 mc. The last stage, V709, is an output amplifier. The amplified signal is directly coupled by coaxial cable to the crystal mixer CR301 input of the wide band amplifier. Since the driving voltage applied to the reactance modulator stage V701 is a sawtooth in time, the output of the reactance modulator stage varies linearly in frequency with time. Change in output frequency (frequency dispersion), set by means of the front panel DISPERSION control, may be as narrow as 400 kc, or

as wide as 25 mc, when a Model STU-2 through STU-5, or the 55-1,000 mc band of the Model STU-1 RF Tuning Unit is used with the spectrum analyzer. When the 10-55 mc range of the Model STU - 1 Tuning Unit is used, relay K501 is automatically energized to limit the maximum pass band displayed to 5 mc.

4-8. MARKER OSCILLATOR.

The variable frequency marker oscillator subchassis is mounted directly to the right side of the cathode ray tube, as viewed from the front of the equipment. The function of the marker oscillator is to provide a variable frequency marker for calibrating the spectrum display and to help determine frequency differences. This circuit employs a twin-triode 6J6 tube, designated V401, having a center frequency of 288 mc, with a tuning range 14 mc above and below its center frequency. The output of the marker oscillator is fed to crystal mixer CR301. With the FREQUENCY DIFFERENCE tuning knob set to its zero calibration mark, and with the marker toggle switch set to its ON position the oscillator produces an output of 288 mc, which appears as a positive pip on the spectrum display. This pip marks the center of the receiver pass-band, i.e., the frequency to which the tuning unit is set. Rotating the FREQUENCY DIFFERENCE dial causes this marker to move along the frequency scale on the CRT screen in accordance with its tuning dial calibrations. Since the sweeper circuit is centered to produce an output of 224 mc, and the output of the marker oscillator is also applied to the crystal mixer CR301 in the wide band amplifier, a beat frequency of 64 mc is obtained at the output of the mixer tube. This 64 mc beat signal is amplified and converted to lower i-f signals through the narrow band to appear as a vertical positive pip on the spectrum display screen. Setting the dial to a position other than its zero setting displaces the pip from the center of the pass-band within a range of ±14 mc. The amplitude of the marker oscillator output is set by the MARKER AMPLITUDE control located on the display unit chassis below the oscillator.

4-9. POWER SUPPLIES.

Three regulated power supplies, mounted on the lower subchassis of the Model DU (beneath the cathode ray tube), are available to provide dc power to both the Model DU and the rf tuning unit in use. One of the low-voltage supplies provides electronically regulated 125 and 300 volt positive outputs. Another low-voltage supply provides a 150 volt negative output. The klystron power supply is electronically regulated and provides the klystron cathode* and reflector* with -325 volts and -925 volts, respectively. Model STU - 1 does not use the klystron power supply. A 60-second delay before application of klystron cathode and reflector voltage is provided by delay relay K101 and hold relay K102. The red KLYSTRON pilot light lights upon application of the klystron voltages. The high voltage (CRT) supply provides 2,400 volts positive and 2,400 volts negative voltages i.e., a 4,800 volt potential. Filament voltages are provided by the secondaries of transformer T103. Protection against overloads and short circuits is provided by the 5-ampere fuses in each leg of the power line.

4-10. MECHANICAL DRIVE SYSTEM. (STU-2, STU-3, STU-4, STU-5)

The main drive shaft is friction driven by the TUNING knob through a planetary drive and disc which, together introduce a reduction ratio of approximately 40:1. The main shaft drives the tuning dial, the tracking potentiometer, a switch cam which controls the position of the microswitch,** and the main cam. The main cam, in accordance with its contour, controls the setting of the oscillator choke assembly through a spring-loaded shaft.

*STU-3, STU-4, STU-5; cathode and reflector -1,250 volts and -1,850 volts respectively.
**No switch on STU-5.

SECTION V

MAINTENANCE

5-1. GENERAL.

While extraordinary care has been taken in the manufacture of the Polarad Model TSA Spectrum Analyzer and each unit is laboratory tested under strict engineering supervision, it is possible that in the course of use the unit may require checking and servicing. The discussion of principles of operation (Section IV) and tables III and IV (this section) should prove helpful in locating a defect.

WARNING

APPLICATION OF POWER TO THIS EQUIPMENT RESULTS IN VERY HIGH VOLTAGES WHICH ARE DANGEROUS TO LIFE. OBSERVE ALL SAFETY PRECAUTIONS AT ALL TIMES. DO NOT ATTEMPT TO REMOVE THE KLYSTRON TUBE FROM ITS CAVITY WHILE POWER IS APPLIED.

5-2. ACCESS TO THE EQUIPMENT.

CAUTION

EXERCISE CARE WHEN WITHDRAWING THE TUNING UNIT. DO NOT FORCE.

Access to the components of the rf tuning unit may be obtained by first setting the tuning dial to the extreme high frequency end, by turning the four camloc screws (located under the handles on the front panel) a half turn counterclockwise and then carefully manipulating the tuning unit left and right as it is withdrawn from the main chassis. The two chassis may then be completely separated by disconnecting the plugs on the two interconnecting cables. Access to all other components may then be obtained by removal of the dust cover. To remove the dust cover, turn the two camloc screws (located at the rear) a half turn counterclockwise and slide the main chassis out of the dust cover.

5-3. PERFORMANCE DATA.

Performance data of the spectrum analyzer depends upon the settings of the following controls. Adjust as indicated before data is taken.

Control	Setting
POWER	ON
FREQUENCY DISPERSION	25 mc (No. 8 on dial)
SWEEP SPEED	20 cps
IF. GAIN	Maximum clockwise
SYNC SELECTOR	LINE
VERTICAL GAIN	Maximum clockwise
HORIZONTAL GAIN	Trace set to 1 screen diameter

TABLE III. PERFORMANCE DATA

Circuit Characteristic	Input Signal or Meter	Applied to	Normal Vertical Deflection or Reading
Vertical amplifier gain.	60 cps, 1.0 volt peak-to-peak amplitude.	Jack J513* (on video chassis).	Approximately 2 inches on display.
Gain from narrow band amplifier sub-chassis input.	64 mc (nominal), 30% modulated at 400 cps of 15 microvolts amplitude.	Jack J211* (on narrow band chassis).	Approximately 1 inch. (Tune signal source for maximum output.)
Gain from marker input at 64 mc.	64 mc (nominal), 30% modulated at 400 cps of 30 microvolts amplitude.	Jack J309* (on wide band chassis).	Approximately 1 inch. (Tune signal source for maximum output.)
Gain from marker input at 160 mc.	160 mc unmodulated, at an amplitude of 150 microvolts.	Jack J309*.	Approximately 1 inch. (Tune signal source for maximum output.)
Gain from wide band input.	160 mc unmodulated at an amplitude of 2 microvolts.	Jack J307* (on wide band chassis).	Signal plus noise should equal twice noise.
Sweeper and i-f alignment.	Signal varied from 148 to 172 mc.	Jack J307*.	Amplitude of the pip on display screen remains within the limits of ±3 db.
Sweeper linearity.	Three unmodulated signals, 148 mc, 160 mc, 172 mc simultaneously applied.	Jack J307*	Distance from 148 mc signal to 160 mc signal should be within 15% of the distance from the 160 to the 172 mc signal.
Operation of crystal in rf unit crystal	Milliammeter (50-100 ohms internal resistance).	Jack J125 (located on power supply.	Milliammeter reading greater than .1 ma.

*Remove plug to make connection to jack.

5-4. TROUBLE SHOOTING.

Table IV lists trouble symptoms and corrective measures as an aid in localizing a defect to a particular circuit.

TABLE IV. TROUBLE SHOOTING

Symptom	Probable Cause	Remedy
Low noise level. Spectrum appears when signal is applied.	Low gain in DU.	Examine tubes V301 to V304 and V201 to V205 for filament failure. Replace defective tube.
		Check the gain of the vertical deflection amplifiers, narrow band i-f, amplifier and mixer, the sweeper and i-f against the data in paragraph 5-3 to locate defective section. Substitute tubes, realign and trouble shoot defective section, as required.
Low noise level and no signal.	Defective wide band i-f amplifier, sweeper or sweeper drive circuits.	Check for presence of marker. If marker appears, trouble is in the wide band amplifier, V301, V302, and V303.
	224 mc sweeper.	If the marker does not appear, the trouble is in the sweeper or the sweeper drive.
		Check for presence of sawtooth at Jack J719. If sawtooth is present, check the 224 mc sweeper circuit.
	Sweeper drive.	If sawtooth is not present, check the sweeper drive circuit, V507.

TABLE IV. TROUBLE SHOOTING (Cont.)

Symptom	Probable Cause	Remedy
Low signal to noise ratio.	Defective crystal mixer in rf tuner.	Replace crystal. (Refer to table III for operational check.)
	Incorrect klystron anode voltage*.	Readjust anode voltage control tube V105 or voltage reference tubes V107 to V110 as required.
Noise normal but no signal.	Defective crystal mixer in rf tuning unit.	Replace crystal.
	Klystron power supply not operating*.	Readjust anode voltage control. Refer to table VI.
		Replace defective voltage control tube V105 or voltage reference tubes V107 to V110 as required.
		Replace defective delay circuit relay K101, K102 or power supply tube as required. Refer to table VI for voltage checks.
	Defective Klystron*.	Replace Klystron tube.
Poor frequency linearity.	Misalignment of 224 mc sweeper.	Refer to alignment procedure (par. 5-10).
Inability to obtain full dispersion.	Incorrect setting of dispersion limit potentiometer.	Readjust potentiometer R549 or R550 (par. 5-7).
	Defective reactance tube V701, oscillator V702, phantastron V505 or sweeper drive V507.	
Poor amplitude linearity.	Wideband i-f amplifier defective or out of alignment.	Replace defective tube or realign as required.
	Sweeper circuit out of alignment.	Adjust C738, (on sweeper chassis) until a linear response is obtained.
Hum on base line.	Low voltage power supply	Check voltage and ripple of the +125 volt and +300 volt outputs.
Low intensity of spectrum or no trace.	High voltage (CRT) power supply.	Check to see that high voltage lead is connected to CRT.
		Check (CRT) power supply voltages.
		Check +300 volt output of low voltage supply.
		Check tubes V117, V120, V122, and V123. Replace defective tube as required.
Spot fixed in center of screen.	Low voltage power supply.	Check +125 volt output.
		Check tube V114 & V115 and the setting of R147, the voltage adjustment.
No horizontal deflection.	Horizontal sweep circuits.	Check tubes V501, V502, V505, V506. Replace defective tube as required.
No vertical deflection.	224 mc sweeper, vertical deflection or narrow band i-f circuits.	Check the 224 mc sweeper.
		Check tubes V503 and V504.
		Check the narrow band amplifier.

TABLE IV. TROUBLE SHOOTING (Cont.)

Symptom	Probable Cause	Remedy
Signal "break up". (Unusually high incidental FM).	Defective reactance or oscillator tube in 224 mc sweeper.	If the incidental fm is more than 20 kc replace V701 and/or V702.
	Excessive ripple in klystron power supply*.	If fm is less than 20 kc check klystron power supply for ripple.
		With no external signal, use the MARKER as the applied signal and measure the incidental fm. Refer to step e., paragraph 3-2.
No marker but rf signal appears on screen.	Marker oscillator inoperative.	Replace tube V401.
No rf sensitivity for portions of the tuning range (dead spots).	Local oscillator tube in rf tuning unit defective.	Recenter modes or replace the local oscillator.
	Klystron power supply*.	Check reflector voltage supply at pin 8 of jack J124 and refer to the repeller tracking procedure for the rf tuning unit.
Overheating	Dirty filter.	Clean filter.
Rotating the HOR GAIN changes the horizontal position.	D-c balance not properly set.	Readjust H. BAL control on front panel.
Marker cannot be centered with the FREQUENCY control (FREQUENCY DIFFERENCE control set at "0".)	Defective or misadjusted frequency centering positive or negative limit potentiometer.	Readjust R558 or R561. Replace defective part. Refer to paragraph 5-12.

*STU-2 through STU-5 only.

5-5. POWER SUPPLY ADJUSTMENTS.

The adjustments for the power supplies are located on the right hand side of the chassis (when facing the display screen). Table V lists the adjustments, test points and normal voltages.

TABLE V. POWER SUPPLY ADJUSTMENTS

Adjustment	Test Points		Normal Voltages
	from	to	
Anode volts	Pin 7 of test jack J124 (located at rear of chassis).		-1,250 for STU-3, STU-4 and STU-5.
325 V Adj.	Pin 7 of J124.	Chassis	-325 for STU-2*.
+125 V	Pin 3 of J124.	ground	+125
+300 V	Pin 2 of J124.		+300

*Set the 1,250 volt supply before setting the 325 volt supply (where the TSA is used with the STU-2 and STU-3, -4 or -5). When making the adjustment the appropriate rf unit must be installed.

5-6. BLANKING WIDTH ADJUST R562.

Remove plug P513 from input jack J513 on the video chassis. Apply a sine wave signal through a capacitor to J513. Set the SWEEP SPEED control to minimum (maximum counterclockwise) and adjust R562, if necessary, until the retrace disappears. Recheck at 30 cycles and 1 cycle sweep.

5-7. SETTING THE HIGH DISPERSION LIMIT ADJUSTMENTS.

a. The high dispersion limit is 25 mc for all five rf tuning units except the 10 mc to 55 mc range of the Model STU - 1. In this range the limit is 5 mc. When setting the 5 mc high dispersion limit adjustment, the Model STU - 1 Tuning Unit must be installed and tuned to the low (10 mc to 55 mc) range. When setting the 25 mc high dispersion limit, the Model STU - 1 Tuning Unit, if connected, must be set to its middle or high range. There is no special frequency setting for the other rf tuning units.

b. To set the 25 mc high dispersion limit adjustment R549 or the 5 mc high dispersion limit R550 proceed as follows:

(1) Remove P307 from jack J307 on the wide band amplifier chassis and apply a 160 mc signal of known accuracy to J307.
(2) Turn the POWER and MARKER switches to ON and allow a 30 minute warmup period.
(3) Adjust the CENTER FREQUENCY control to center the 160 mc signal on the display screen.
(4) Set the FREQUENCY DIFFERENCE control to "0" and superimpose the marker pip upon the 160 mc signal. If it does not superimpose, recalibrate the marker. Refer to paragraph 5-12.
(5) Set the DISPERSION control to 8.
(6) Rotate the FREQUENCY DIFFERENCE control 12.5 mcs (2.5 mc for the 5 mc limit) clockwise and counterclockwise from its center setting. The marker pip should move to one end of the display screen and then to the other.
(7) If necessary, adjust the high dispersion limit adjustment to obtain a dispersion of 25 megacycles. If unable to do so, check the sweep linearity and readjust the linearity, if required.

5-8. FREQUENCY CENTERING NEGATIVE AND POSITIVE LIMIT ADJUSTMENTS.

a. The negative limit adjustment R558 and the positive limit adjustment R561 are located on the video chassis. To set these adjustments proceed as follows:

(1) Set the FREQUENCY DIFFERENCE control at "0".
(2) Rotate the COARSE section of the CENTER FREQUENCY control fully clockwise and then counterclockwise. The marker pip should move to one extreme end of the screen and then to the other. If it does not, vary the limit adjustments R558B and R561 until the marker pip is set at the ends of the screen with the rotation of the COARSE section of the CENTER FREQUENCY control.

5-9. NARROW BAND CHASSIS ALIGNMENT PROCEDURE.

a. Alignment of the narrow band chassis follows:

(1) Connect a 64 mc signal source, 30% modulated at a frequency of 400 cps to jack J211 (located on the narrow band chassis), the input to the narrow band amplifier.
(2) Apply sufficient output from the source to display a signal.
(3) Vary the tuning slugs located on the narrow band chassis, in the following sequence, until the displayed signal reaches maximum amplitude: 1st - L201; 2nd - L202; 3rd - L206 top; 4th - L206 bottom; 5th - L213; 6th - L210; 7th - L215 and 8th - L219.
(4) For best results, repeat the entire alignment procedure at least once.

Note. Be sure to tighten all locknuts after each adjustment.

5-10. 224 MC SWEEPER ALIGNMENT.

a. Alignment of the 224 mc sweeper follows:

(1) Remove the sweeper strip from the right side frame of the Model DU directly above the narrow band chassis (fig. 7). Then remove the dust cover surrounding the sides and bottom of the strip so that the terminals on the tube sockets on the under side of the chassis are accessible.
(2) Set the DISPERSION control fully counterclockwise and rotate the HOR GAIN control so that the sweep trace covers the entire width of the display screen.
(3) Insert the probe of a high-impedance, d-c vacuum-tube voltmeter into the BIAS TEST pin jack J719, located near V701. A bias voltage of about 8 volts is required. Rotate the CENTER FREQUENCY control on the front panel until the proper voltage indication is observed on the voltmeter.
(4) Place a wavemeter, tuned to 28 mc in the vicinity of L701 (at the output of V702). Tune the L701 adjustment screw until the wavemeter indicates resonance. (The inductance, L718, in the cathode circuit of V701 controls low-frequency sweep linearity, while the bifilar winding, T701 controls sweep sensitivity.) If the oscillator fails to produce an output, tubes V701 and/or V702 may have to be changed.
(5) After the oscillator has been properly tuned to 28 mc, connect the vacuum-tube voltmeter, through the 1-megohm resistor, to the grid of V704. Tune L702 and L703 adjustment until a maximum reading is obtained on the VTVM.
(6) Connect the VTVM to the grid of V705 through the 1-megohm resistor, and tune L704 for maximum output.
(7) Repeat the procedure of step (6) above, for the remaining tubes V705 through V709, and inductors L705 through L711.
(8) Set the DISPERSION control maximum clockwise and adjust capacitor C738 and the tuning slug of inductor L712 to give maximum amplitude and flatness of noise across the screen.
(9) Check the linearity by proceeding as follows:
    (a) Set the FREQUENCY DISPERSION control to 8.
    (b) Apply a 60 cps voltage to the vertical amplifier at jack J513.
    (c) Set the SWEEP SPEED control to 20 cps (to give 3 cycles on the display screen).
    (d) Remove the 60 cps voltage and reconnect plug P513 to jack J513.
    (e) Apply a 160 cw signal (known to be accurate) to jack J307, the input to the wide band amplifier.
    (f) Vary the CENTER FREQUENCY control to center the 160 mc cw pip on the display screen. (See fig. 4.)

(g) Set the FREQUENCY DIFFERENCE control at "0" to align the marker pip with the 160 mc cw signal. If it does not align, refer to paragraph 5-12 and recalibrate the marker.
(h) Remove the 160 mc cw signal and apply a 172.5 mc cw signal (known to be accurate) to jack J307. If the 172.5 mc signal does not appear see step (10).
(i) Use a T-connector at jack J307 and apply a second 172.5 mc cw signal, aligning the second signal with the first on the screen.
(j) Replace the first 172.5 mc cw signal of known accuracy with a 147.5 mc cw signal of known accuracy. If the 147.5 mc signal does not appear see step (10) below.
(k) The display screen should now present three pips, one at the center of the scale and one at each end of the scale. This represents a linear condition of the 224 mc sweeper.

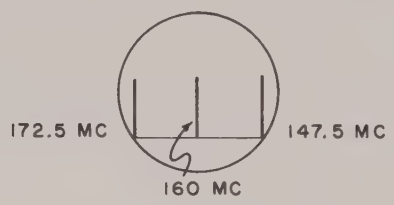


Figure 4. 224 MC Sweeper Linearity Check

(10) If the 172.5 mc signal pip does not appear on the display screen or if it is not directly on the end of the scale, adjust L701 until the pip is properly placed. If the 147.5 mc signal does not appear or is not directly on the end of the scale, adjust L718 and T701 until the pip is properly placed. Retune L702, as directed in step (5) above, after readjusting L718 and/or T701. If necessary change tube V701 and/or V702 to obtain satisfactory sweep linearity.

Note. In general, increasing the inductance of L718 and T701 increase sweep range and sensitivity (frequency deviation) per bias change at the expense of weakening the output from the sweep oscillator.

(11) Recheck the amplitude as directed in step (8).

5-11. WIDE BAND AMPLIFIER CHASSIS ALIGNMENT.

a. The wide band amplifier chassis is located on the right hand side at the Model DU frame (when facing the display screen) and is directly in front of the 224 mc sweeper chassis and the narrow band i-f chassis. The chassis contains the wide band amplifier (a three-stage stagger-tuned circuit), a mixer and the first stage of the narrow band amplifier. Remove the chassis by unscrewing the four mounting screws. Disconnect the RG-55/U cable termination on P307 from the input receptacle J307 on the chassis. Do not remove the other cable connections. A signal generator within the frequency range from 64 mc to 171 mc is required. Alignment is performed by observing the signal pip on the display screen. Proceed as follows:

(1) Connect the output of the signal generator through a suitable pad (providing at least 6 db attenuation) to the input receptacle J307.
(2) Turn the POWER switch to ON and allow a 30-minute warmup period.
(3) Set the controls on the signal generator to produce a cw signal of 64 mc and tune the two adjustment screws marked L322 and L324 until maximum output is obtained, as indicated by the amplitude of the pip on the display screen.
(4) Adjust wave trap L326 for minimum output.
(5) Set the signal generator frequency to 171 mc and tune L321 for maximum output.
(6) Set the signal generator to 149 mc and tune L320 for maximum output.
(7) Set the signal generator to 160 mc and tune L319 for maximum output.
(8) For optimum adjustment construct a response curve by varying the signal generator over the range 149 mc to 171 mc, noting the output voltage at several frequencies; and if necessary slightly retune the 160 mc inductance L319. The bandwidth is approximately 25 mc at the 3 db points.

5-12. MARKER ZERO SETTING.

With the FREQUENCY DIFFERENCE control set to "0" and a 160 mc signal of known accuracy applied to J307, two signals should zero beat. If they do not, adjust C402 (on the marker chassis) for zero beat.

5-13. KLYSTRON TUBE REPLACEMENT.

The klystron tube is partially seated within the oscillator cavity which is assembled on the casting directly to the rear of the rf unit front panel. Replacement procedure follows:

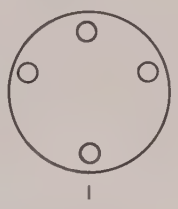
a. Remove the Klystron Tube.

(1) BE SURE TO TURN OPERATING POWER OFF. Remove the rf tuning unit from the main chassis.
(2) Remove the breeze clamp holding the klystron protective cover to the klystron retainer nut and slide the cover back along the socket lead cable.

(3) Gently pull the tube socket assembly away from the base of the klystron tube.
(4) Use the spanner wrench supplied with the equipment to loosen the knurled collar at the end of the cavity. DO NOT REMOVE THE COLLAR COMPLETELY.
(5) Grasp the projecting end of the klystron tube, gently rotating it in a clockwise direction while simultaneously withdrawing the tube from its spring finger holders within the cavity.

b. Insert Replacement Klystron.

(1) Insert the tube carefully within the center of the cavity, and press it all the way in, rotating clockwise against a noticeable resistance as the internal contact ring-fingers make engagement, until it meets a positive stop*.
(2) Then re-tighten the large knurled collar, using the spanner wrench.
(3) Connect the socket to the base of the klystron tube. Use care to avoid breaking or bending the tube pins as the socket can be forced on in the wrong position (the tube will not operate in this case). (Pin No. 1 is the pin apart from the other three.)



(4) Replace the klystron protective cover by clamping it in place with the breeze clamp.
(5) Rotate the Anode Current screwdriver control to its extreme counterclockwise position.

5-14. REPELLER VOLTAGE TRACKING ADJUSTMENTS. (STU-2, -3, -4 and -5.) (See figures 5 and 6.)

a. The repeller voltage tracking procedure which follows assumes that the unit was previously aligned and operating but that the klystron was changed. To set the repeller tracking voltages a modulator, a phase shift circuit, a voltmeter and a high gain oscilloscope are required. The preliminary set-up follows:

(1) Check the power supply reflector voltage** at pin 8 of J124, located at the rear of the main chassis, Model DU. Check the anode voltage*** at pin 7 of J124. Readjust if necessary.

*In the Models STU-3, STU-4 and STU-5, there will be two clicks before the tube meets the stop.
**-925 volts for STU-2; -1850 volts for STU-3 through STU-5.
***-325 volts for STU-2; -1250 volts for STU-3 through STU-5.

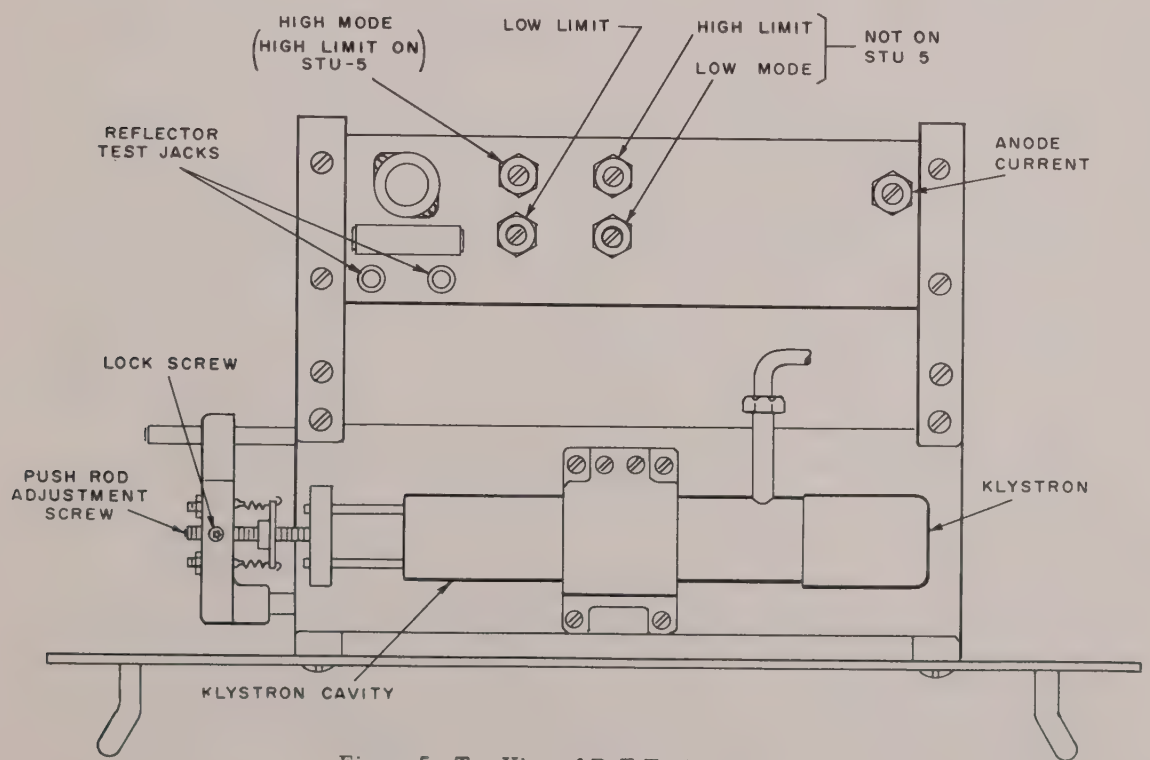


Figure 5. Top View of R-F Tuning Unit

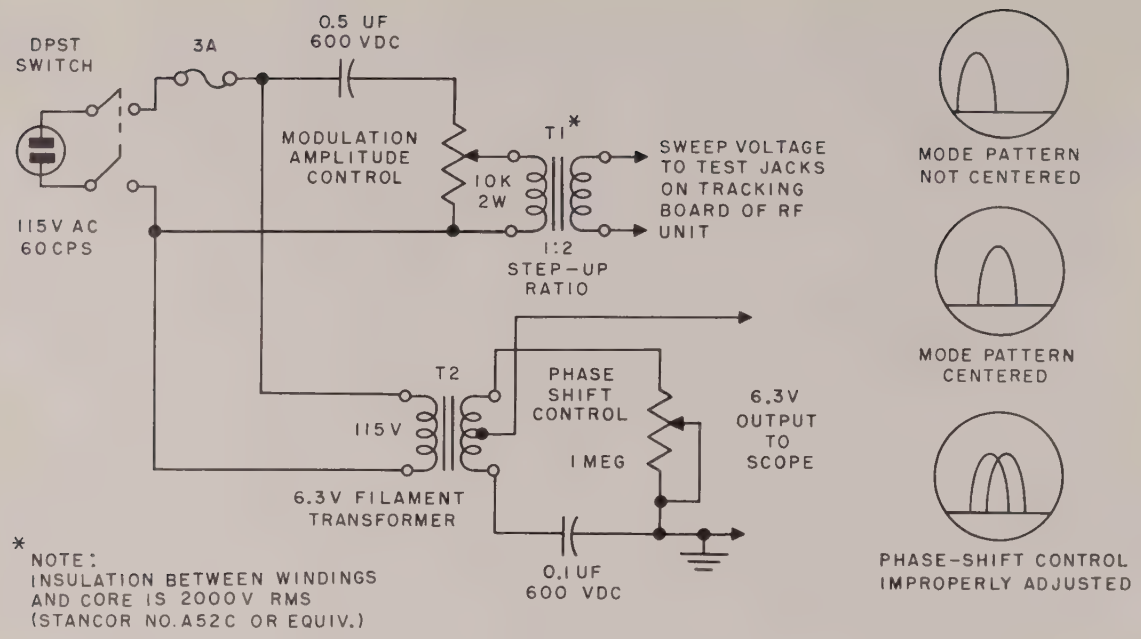


Figure 6. Modulator and Phase Shifting Circuits - Schematic Diagram

(2) With the power OFF make the following connections:
   (a) Connect the modulator to the reflector test jacks.
   (b) Connect the phase shifting circuit to the EXT H sweep input of the oscilloscope.
   (c) Connect the output of the crystal mixer to the vertical input of the oscilloscope. The output is available at the 160 mc output jack.
   (d) For STU-2: Connect the negative terminal of a d-c voltmeter to pin 1 and the positive terminal to pin 2 of R801, the Anode Current Adj. potentiometer. For STU-3: Connect the positive lead of a d-c voltmeter to pin 4 of jack J124 and the negative lead to chassis ground.

(3) Refer to table VI to set the repeller tracking voltages.

TABLE VI. SETTING THE REPELLER TRACKING VOLTAGES

STEP	Adjustment	Adjustment Location	Normal Indication
1	Set Power switch to ON position. Wait approximately 1-minute for the delay relay to complete its cycle.	Front Panel	a. POWER indicator lights. b. After the one-minute delay period the KLYSTRON indicator lights.
2	Adjust the Anode Current Adj. potentiometer clockwise.	Reflector control board on rear of oscillator housing.	D-c voltmeter reads 10v between pins 1 and 3 of V801 (STU-2);2v between pin 4 of J124 and gnd for STU-3,-4,-5.
3	Rotate TUNING knob to set freq. dial to high end.	Tuning Unit front panel.	Calibration mark*, appears under the index hairline.
4	Adjust the Modulation Amplitude and phase control pots.	Modulator Unit (fig. 6).	A single mode pattern appears on the screen.
5	Adjust the HIGH-LIMIT screwdriver control.	Reflector control board on rear of oscillator housing.	The mode moves to the center of the screen.
6	Rotate TUNING knob to set freq. dial to low end.	Tuning Unit front panel.	Calibration mark** appears under the index hairline.
7	Increase the Modulation Amplitude and adjust the phase control.	Modulator Unit.	A single mode pattern appears on the screen.

TABLE VI. SETTING THE REPELLER TRACKING VOLTAGES (Cont.)

STEP	Adjustment	Adjustment Location	Normal Indication
8	Adjust the LOW-LIMIT screwdriver control.	Reflector control board on rear of oscillator housing.	The mode moves to the center of the screen#.
9	Rotate Tuning knob to high freq. side of mode switch, just after it clicks.	Tuning Unit front panel.	Dial is set at about -1,250 mc for STU-2; -7,800 mc for STU-3; -23,240 mc for STU-4.
10	Adjust the Modulation Amplitude and phase control pots.	Modulator Unit	A single mode pattern appears on the screen.
11	Adjust the screwdriver control marked HIGH-MODE for Models STU-2, -3, -4.	Reflector control board on rear of oscillator housing.	The mode moves to the center of the screen.
12	Rotate the Tuning knob to the low frequency side of the mode switch, just after it clicks.	Tuning Unit front panel.	Dial is set at approximately -1,250 mc for STU-2; -7,800 mc for STU-3; -23,240 mc for STU-4;
13	Adjust the Modulation Amplitude and phase control pots.	Modulator Unit.	A single mode pattern appears on the screen.
14	Adjust screwdriver control marked LOW-MODE Models STU-2, -3, -4.	Reflector control board on rear of oscillator housing.	The mode pattern moves to the center of the screen.
15	Repeat steps 3 through 14 until no further adjustment is required.		The modes remain centered without further adjustment as the steps are repeated.

*2, 200 mc (on low range) for STU-2; 10, 920 mc (on low range) for STU-3; 33, 000 mc for STU-4; 44, 000 mc for STU-5.

**910 mc for STU-2; 4, 370 mc for STU-3; 21, 000 mc for STU-4; 33, 000 mc for STU-5.

#This step completes the repeller tracking voltage procedure for Model STU-5; and Model STU-2, serial numbers 308 and above. Check by repeating steps 3 through 8.

5-15 FREQUENCY IN MEGACYCLES DIAL ADJUSTMENT.

a. For Models STU-2, STU-3, STU-4 and STU-5, proceed as directed in table VII. The dial adjustment which follows assumes that the unit was previously aligned and operating but that the klystron was changed. To calibrate the FREQUENCY IN MEGACYCLES dial, the following equipment is required.

(1) A signal generator covering the required range.
(2) A high gain oscilloscope.

b. For Model STU - 1 the dial frequency calibration which follows assumes that the unit was previously aligned and operating but that the local oscillator tube V601, was changed. A signal generator at the frequencies 10 and 400 mc is required. Proceed as follows:

(1) Withdraw the Model STU - 1 from the main chassis (par. 5-2).
(2) Set up the spectrum analyzer for operation (par. 3-2). The input signal should be a 400 mc signal of known accuracy.
(3) Rotate the TUNING knob to set the frequency dial at the high frequency side. Tune in the signal so that it coincides with the marker pip at the center of the display screen (frequency dial at approximately 400 mc).
(4) Loosen the two set screws holding the frequency dial hub to its shaft. Turn the dial on the shaft until the 400 mc mark is at the hairline. Hold the dial fixed in position and tighten one of the set screws. Then tighten the other set screw.
(5) Set the Model STU - 1 on its side so that the bottom is accessible. Set the frequency dial to 10 mc. Apply a 10 mc input signal of known accuracy.
(6) Remove the plug button covering the access hole to the tracking capacitor (the access hole is located on the bottom of the rf unit cover). Adjust the tracking capacitor until the input signal pip coincides with the marker signal pip at the center of the display. The FREQUENCY IN MEGACYCLES dial is now fully calibrated.

TABLE VII. TUNING DIAL ADJUSTMENT PROCEDURE

STEP	Adjustment	Adjustment Location	Normal Indication
1	Connect the signal generator to the DIRECT RF INPUT jack. Set POWER switch to ON and wait 1 minute.	Front Panel.	a. Power indicator lights. b. After the 1-minute delay period, the KLYSTRON indicator lights.
2	Set MARKER switch to ON, MARKER AMPLITUDE to 2 inch deflection, FREQUENCY DIFFERENCE to zero and the DISPERSION control to 8.	Front Panel.	The marker pip should appear at the center of the spectrum display screen. If not centered, adjust to center with the CENTER FREQUENCY control.
3	Rotate the Tuning knob to the high frequency end of the tuning dial and tune the signal generator tuning dial to the same frequency.	Front Panel and Signal generator.	A second pip appears on the Spectrum Display Unit screen.
4	Tune the signal generator so that the pips coincide.	Signal generator.	Record signal generator frequency (actual frequency) as against dial frequency.
5	Repeat steps 3 and 4 for all frequencies indicated on the low scale of the tuning dial.	Front Panel and Signal generator.	The true frequency should be within 1% of the dial frequency at all points. If not, proceed to step 6.
6	Set the dial reading and the wavemeter*.	Signal source front panel and wavemeter knob.	Pip appears on mode.
7	Loosen the No. 6 set screw which locks the top push rod adjustment screw (fig. 5).	Oscillator push plate.	Pip should remain on the mode.
8	Adjust the push rod adjustment screw to center the mode.	On oscillator push plate.	The pip should be centered.
9	Lock the push rod adjustment screw in place by tightening the No. 6 set screw.	On oscillator push plate.	The pip should remain centered on the mode.
10	Repeat steps 1 to 5 above and the repeller tracking procedure.		Tuning Unit should be accurately calibrated.

*STU-2 - 1600 mc; STU-3 - 8000 mc; STU-4 - 27,500 mc; STU-5 - 39,000 mc. Calibrating the dial at these frequencies will normally set both the high and low frequency extremes within ±1%. With some klystrons, however, it may be necessary to compensate. For example, the dial might be set to slightly below 8000 mc, for the STU-3, to compensate for an out of tolerance (+1%) reading at one extreme. Care must be taken that the other extreme is not set out of tolerance and step 5 should be repeated as a check.

5-16. WIDE BAND-PASS FILTER ALIGNMENT.

To align the wide band-pass filter, proceed as follows:

a. Connect the output of a signal generator to the DIRECT RF INPUT connector on the front panel.
b. Turn the POWER switch to ON and allow a 30-minute warm-up period.
c. Tune the signal generator to 160 mc.
d. Tune L604 for maximum output, as observed on the display screen.
e. Set the signal generator frequency to 147.5 mc.
f. Tune C603 and then C605 for maximum output. Note which capacitor has the smaller effect.
g. Set the signal generator frequency to 172.5 mc and tune that capacitor, which had the smaller effect in the previous step, for maximum output.
h. As there will be interaction between the tuning elements, it will be necessary to repeat the adjustment of L604, C603 and C605 until maximum output is obtained without further adjustment.

5-17. 160 MC NARROW BAND-PASS FILTER ALIGNMENT.

To align the narrow band-pass filter, turn the TUNING control to obtain a frequency below 55 mc. Then proceed as follows:

a. Connect the output of a signal generator to the DIRECT RF INPUT connector on the front panel.
b. Turn the POWER switch to ON and allow a 30-minute warm-up period.
c. Tune the signal generator to 160 mc.
d. Tune L612 for maximum output, as observed on the display screen.
e. Set the signal generator frequency to 157.5 mc.
f. Tune C617 and then C619 for maximum output. Note which capacitor has the smaller effect.
g. Set the signal generator frequency to 162.5 mc and tune that capacitor which had the smaller effect in the previous step, for maximum output.
h. As there will be interaction between the tuning elements, it will be necessary to repeat the adjustment of L612, C617 and C619 until maximum output is obtained without further adjustment.

5-18. LOW-PASS FILTER ALIGNMENT PROCEDURE.

With no signal at the input of the r-f unit, turn to 16 mc on the tuning dial. A spurious signal appears at this frequency. Tune L631 and L632 to reduce the spurious signal to a minimum.

VOLTAGE MEASUREMENTS

All voltages measured to chassis ground unless otherwise noted. Measurements taken with RF Tuning Unit connected, using a 20,000 ohm-per-volt meter. (The klystron power supply does not operate when the STU-1 Tuning Unit is connected.)

TUBE	PIN NUMBER											Remarks
	1	2	3	4	5	6	7	8	9	10	Cap	
V101	0	415	0	-235	0	-235	415	415				STU-2 only
	0	680	0	-580	0	-580	680	680				•
V102	0	-220	0	-900	0	-900	0	-220				STU-2 only
	0	-560	0	-1800	0	-1800	0	-560				•
V103	0	125	-7.8		0							STU-2 only
	0	125	-8.4	3.2*	0							•
V104	0	125	-7.7		0							STU-2 only
	0	125	-8.4	3.2*	0							•
V105	-7.85	-80	-79			-80	-155	-153				STU-2 only
	-8.6	-82	-80			-82	-156	-155				•
V110							-925					STU-2 only
							-1850					•
Jack J124							-325					STU-2 only
							-1250					•
V111		460		400 ac		400 ac		460				
V112	-530		400 ac	400 ac		-530	400 ac					
V113		-150					-150					
V114	80	280	125	80	280	125						
V115	-4	0			80	125	0					
V116		460		400 ac		400 ac		460				
V117		420	300	240	420	300						
V118	-2	0			240	25	0					
V120	3		280		150							
V124 (CRT)		-2200	-2200		-1600		100 to 300	120 to 300	0 to 300	180 to 300	2400	

* At 20 mils
• STU-3, -4, and -5 only.

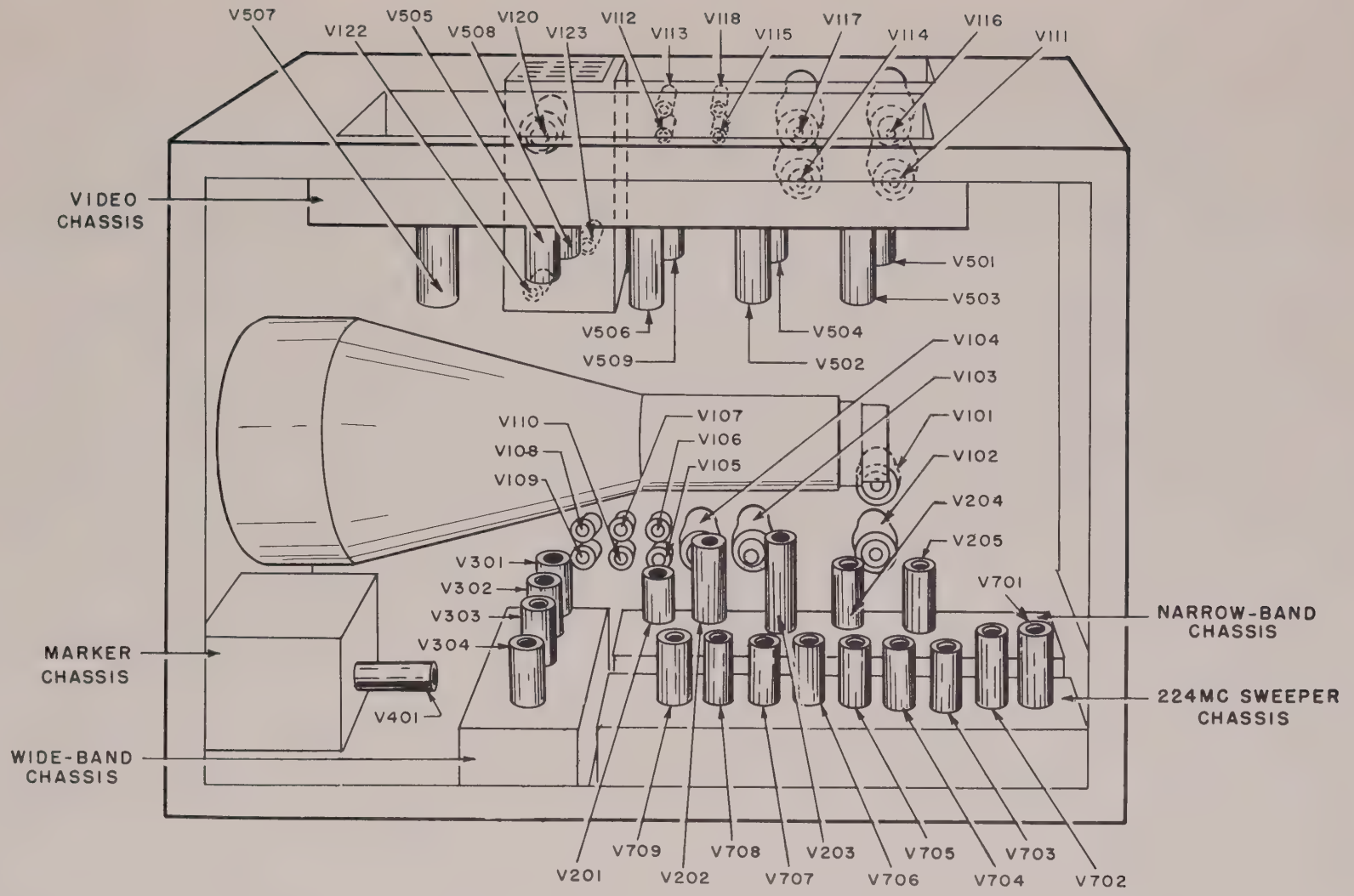


Figure 7. Location of Sub-chassis and Tubes

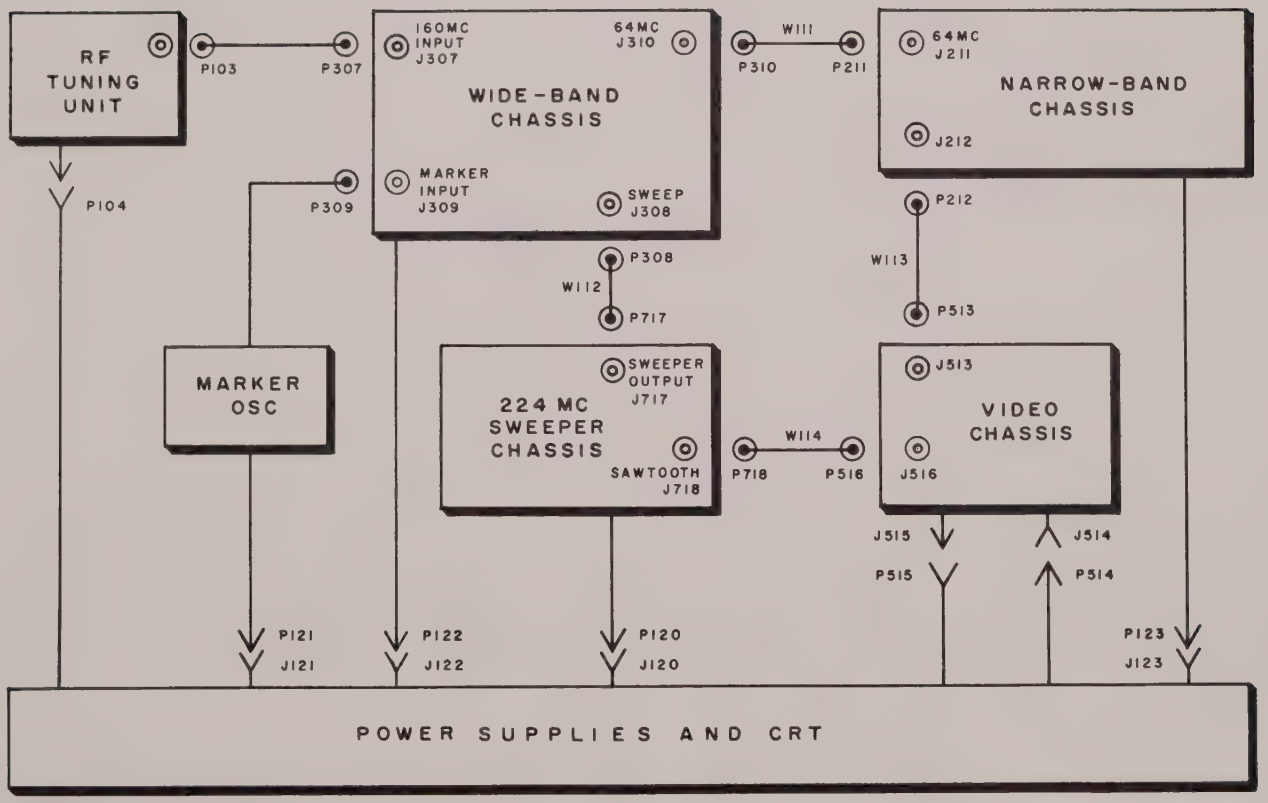


Figure 8. Inter-chassis Cabling Diagram

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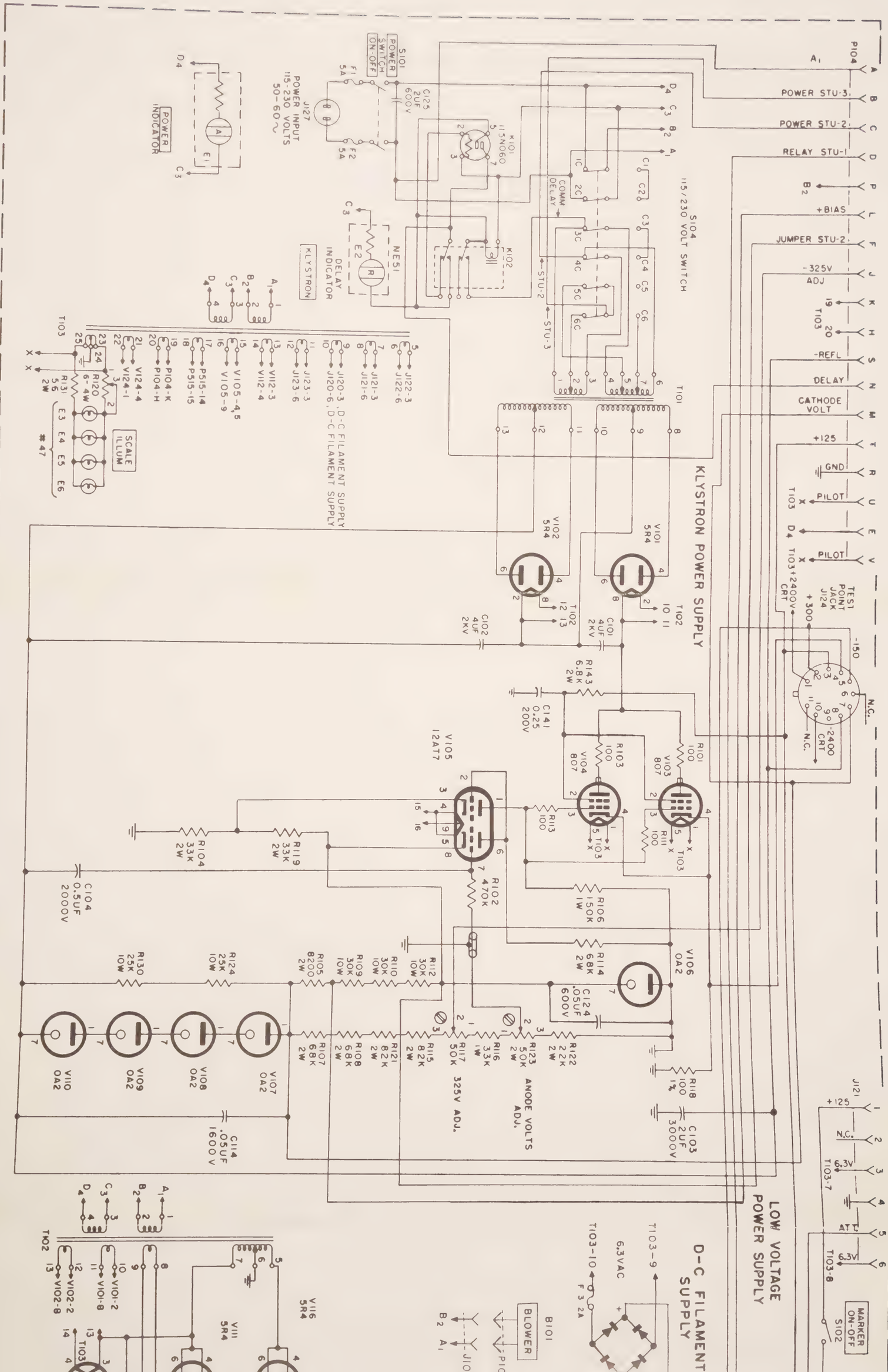
KLYSTRON POWER SUPPLY
LOW VOLTAGE POWER SUPPLY
D-C FILAMENT SUPPLY
S104 115/230 VOLT SWITCH
S101 POWER SWITCH ON-OFF
POWER INDICATOR
DELAY INDICATOR
KLYSTRON
SCALE ILLUM
TEST POINT JACK J124
MARKER ON-OFF S102
BLOWER B101
ANODE VOLTS ADJ.
325V ADJ.
POWER STU-3
POWER STU-2
RELAY STU-1
+BIAS
JUMPER STU-2
-325V ADJ
-REFL
DELAY
CATHODE VOLT
+125
GND
PILOT
PILOT
+2400V CRT
+300
-150
N.C.
2400 CRT
6.3VAC
6.3V
AT
T103-9
T103-10
T103-8
T103-7
T102-8
T102-2
T101-2
T101-8
V102 5R4
V101 5R4
V116 5R4
V111 5R4
V105 12AT7
V104 807
V103 807
V106 0A2
V107 0A2
V108 0A2
V109 0A2
V110 0A2
C125 2UF 600V
C102 4UF 2KV
C101 4UF 2KV
C141 0.25 200V
C104 0.5UF 2000V
C124 .05UF 600V
C114 .05UF 1600V
C103 2UF 3000V
R143 6.8K 2W
R101 100
R103 100
R111 100
R113 100
R102 470K
R106 150K 1W
R114 68K 2W
R104 33K 2W
R119 33K 2W
R130 25K 10W
R124 25K 10W
R105 8200 2W
R109 30K 10W
R110 30K 10W
R112 30K 10W
R107 68K 2W
R108 68K 2W
R121 82K 2W
R115 82K 2W
R116 33K 1W
R117 50K
R123 50K 2W
R122 22K 2W
R118 100 1%
R131 56 2W
R120 6-4W
#47
F1 5A
F2 5A
F 2A
K101 115NO60
K102
NE51
J127 POWER INPUT 115-230 VOLTS 50-60~
J121
J123-3
J123-6
J121-3
J121-6
J122-3
J122-6
J120-3, D-C FILAMENT SUPPLY
J120-6, D-C FILAMENT SUPPLY
P104-K
P104-H
P515-14
P515-15
V105-4,5
V105-9
V112-3
V112-4
V124-4
V124-1
J101
P101

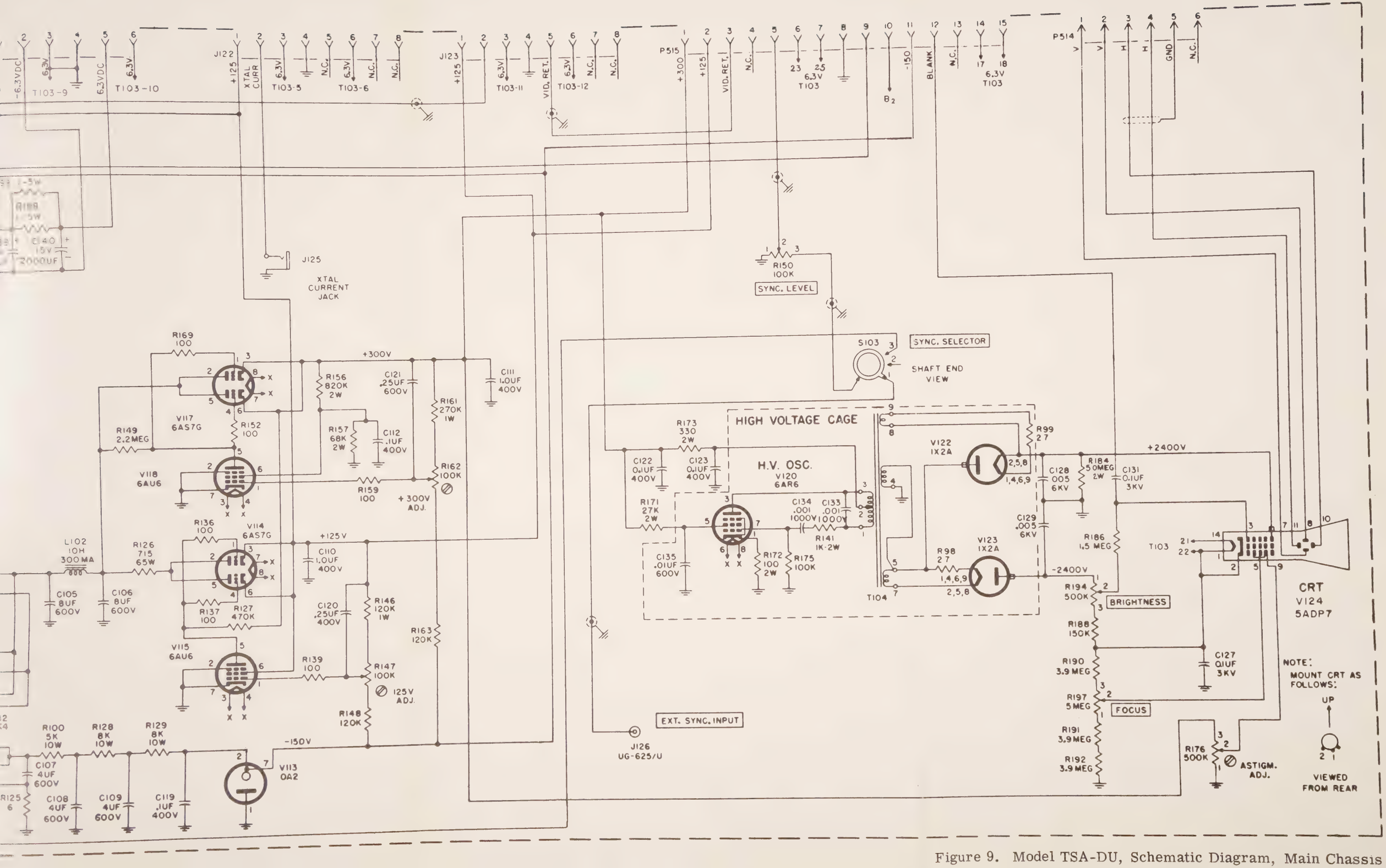

Figure 9. Model TSA-DU, Schematic Diagram, Main Chassis

FROM CRYSTAL MIXER (IN TUNING UNIT)

RG-71/U

UG-261/U

UG-262/U

MIXER OUTPUT

FRONT PANEL JUMPER

RG-71/U

P103

RG-71/U CABLE

P307

UG-262/U

UG-260/U

IF INPUT

WIDE BAND CHASSIS

MARKER OSC.

V401 6J6

MARKER FREQ

MARKER AMPLITUDE

P309

IF GAIN

P121

60MC INPUT

J307 UG-625/U

MARKER INPUT BNC

J309

160MC

149MC

171MC

64MC

64MC NB IF J310 UG-625/U

P310 P211 UG-88/U RG-55/U CABLE

V301 6AJ4

V302 6AJ4

V303 6AJ4

V304 6AK5

C329

CR301 G7A

SWEEPER

J308

P308

P122

224 MC SWEEPER CHASSIS

BIAS J719

T701

28MC

56MC

112MC

+125V

V701 6J4 REACTANCE TUBE

V702 6J6 OSCILLATOR

V703 6AK5 AMPL

V704 6AK5 AMPL

V705 6AK5 DOUBLER

V706 6AK5 AMPL.

V707 6AK5 DOUBLER

JP 24525-2

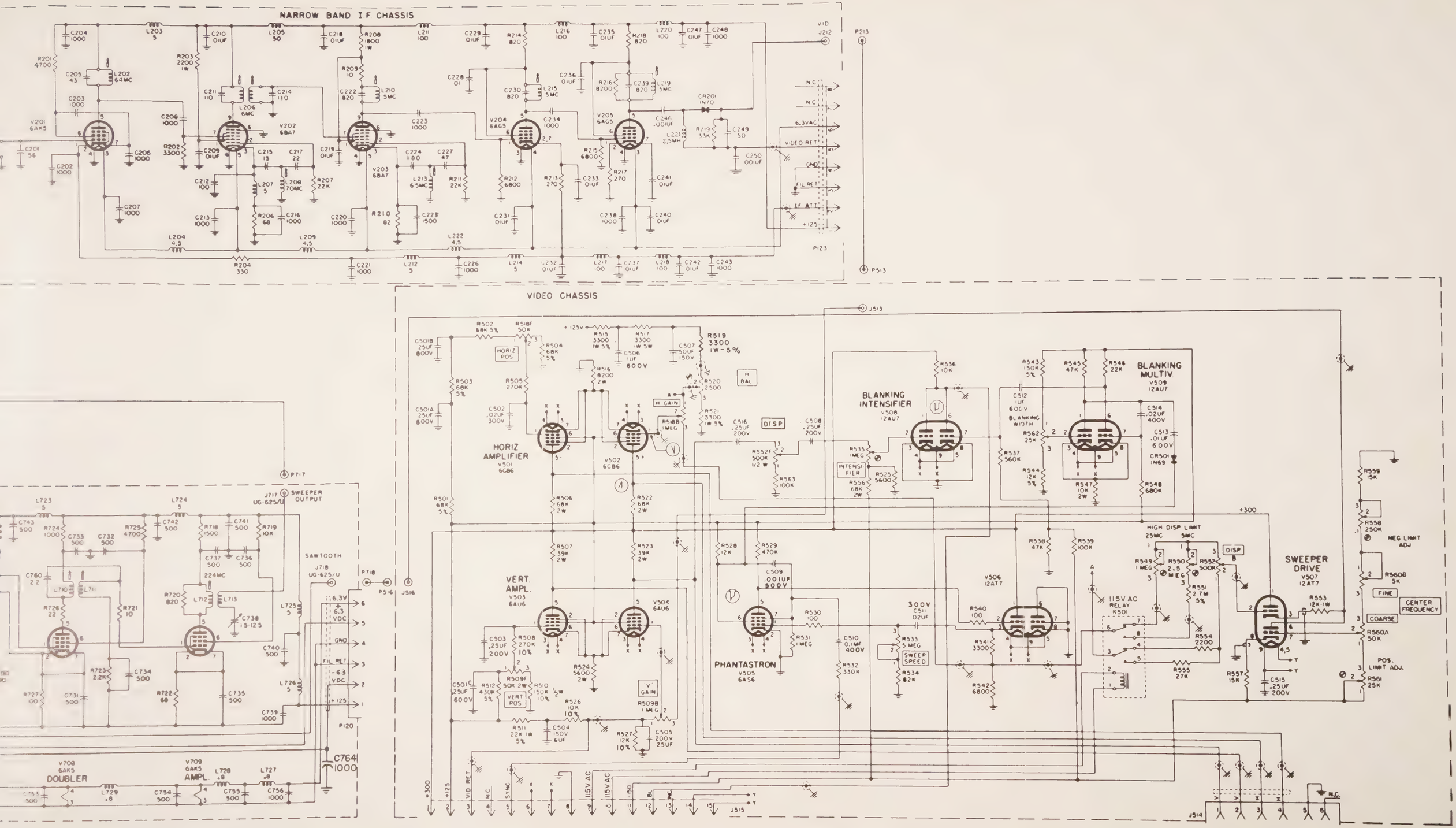

Figure 10. Model TSA-DU, Schematic Diagram, Sub-Chassis

POLARAD ELECTRONICS CORP.

CONSULTANTS — DESIGNERS — MANUFACTURERS

43-20 34th Street Long Island City 1, N. Y.

EXeter 2-4500

REQUEST FOR MAINTENANCE

FROM:

COMPANY NAME _____ DATE: _____

ADDRESS: _____ INDIVIDUAL _____

_____ POSITION _____

SECTION OR DIVISION _____ PHONE NO. _____ EXT. _____

_____

EQUIPMENT _____ DATE OF PURCHASE _____

MODEL _____ SERIAL NO. _____ ORDER NO. _____

_____

TROUBLE REPORT:

A. Description of trouble _____

_____

_____

_____

_____

_____

B. Has trouble been localized? _____ If so, how and where: _____

_____

_____

_____

_____

_____

C. Instruments used and measurements taken, if any: _____

_____

_____

_____

D. Is trouble intermittent? _____

E. Hours of operation prior to this trouble _____

F. Date trouble occurred _____

G. Was factory consulted by telephone or letter prior to this request? _____

If so, give date and person to whom directed: _____

_____

H. Additional Comments: _____

_____

_____

_____

_____

_____

_____

When trouble develops requiring factory assistance, complete this form and send to:

Polarad Electronics Corporation
43-20 34th Street
Long Island City 1, New York
ATTENTION: Service Department

After this report has been analyzed by the Service Department, you will be notified when a field service engineer will call on you to make the necessary repairs. If your trouble can best be corrected at the factory, we will so notify you with instructions and authorization for returning the equipment.

NO EQUIPMENT MAY BE RETURNED TO THE FACTORY WITHOUT WRITTEN AUTHORIZATION

POLARAD

PROVEN RELIABILITY

43-20 34th STREET
LONG ISLAND CITY 1, NEW YORK
EXeter 2-4500

92858